

Case Study 40

Energy efficiency in hospitals: condensing gas boilers

Condensing gas boilers for heating and hot water in hospitals

- Running cost savings of 10 - 20%
- Paybacks under three years
- High efficiencies using conventional system design
- Easy to install and maintain
- Environmentally friendly

Overview

As much as 80% of delivered energy (or about 60 GJ/100m³/yr) in the hospitals sector can be accounted for by fossil fuels, most of which is used for space heating and domestic hot water. Whilst these two uses do not account for anywhere near 80% of the energy cost or primary energy supplied, they provide an opportunity for significant savings.

As more hospitals become NHS Trusts, the responsibility for saving energy and minimising environmental damage is increasingly moving to Unit management, and General Managers are now asking what they can do about these issues. Installing condensing gas boilers is one of the best ways to address both these problems with possible savings of 10-20% in the annual fossil fuel bill and a corresponding reduction in harmful emissions.

On a national basis, hospital fossil fuel use costs roughly £170M each year. This represents a large part of health authority expenditure on energy. If about one-quarter of the existing boiler plant could be replaced by condensing boilers, this could lead to savings of some £4M each year. In general, the necessary additional investment would be repaid within three years.

The overall energy consumption in hospitals results in around 7.5 million

tonnes of CO₂ being emitted into the atmosphere every year, adding to the greenhouse effect. Of this about 5 million tonnes can be attributed to space heating and hot water. Using condensing boilers could reduce this by some 100 000 tonnes/yr and could also help prevent acid rain.

This technology therefore provides a cost-effective way of reducing pollution and conserving natural resources. Three examples of good practice using condensing boilers in hospitals are discussed in this Case Study. The results show that condensing boilers can offer very attractive investment opportunities in a wide range of circumstances.

CARTER BEQUEST HOSPITAL, MIDDLESBROUGH

Construction of the Carter Bequest Hospital was completed in 1925. The site began as a surgical and maternity hospital although today it is a small elderly care hospital. During the 1950s a second building was added which now accommodates 44 beds for the elderly, 11 of which are for the elderly mentally infirm. The two wards, Oxford and Cambridge, each have day rooms and administrative areas in the central portion of the building. The older premises at the front of the site now accommodate the Teeside Hospice Care Foundation. The hospice provides a day centre for up to 16 elderly people suffering from terminal illness and also provides a large charity shop for the local community.

Major renovation of the hospital building took place in 1990 to create a warm and homely environment for the patients. A range of accommodation is provided from single rooms to small sub-divided wards and associated day rooms which give a home from home atmosphere. Food is brought to the hospital via a cook/chill arrangement and there are small kitchen facilities in both the hospital and the hospice.



Carter Bequest Hospital, Middlesbrough



Bolingbroke Hospital, Wandsworth



Bletchley Community Hospital, Nr Milton Keynes

The buildings are generally two-storey medium-weight, brick construction with pitched slate roofs. A part of the refurbishment programme included installing modern double glazing in the hospital.

“Condensing boilers can offer very attractive investment opportunities in a wide range of circumstances”



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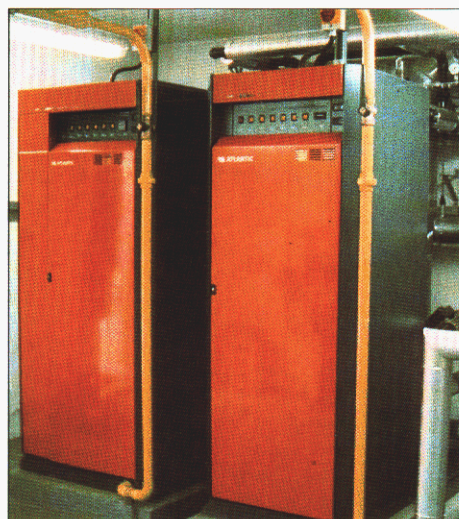
System

A new heating system was installed in October 1990 which included a move to more efficient boiler plant. An Atlantic Condensagaz E174 gas-fired condensing boiler rated at 178-196 kW was installed to provide the base load space heating requirements. Any further demand is supplied by an Atlantic Optimagaz E232 gas-fired, high efficiency, non-condensing boiler rated at 230 kW. Domestic hot water is provided by two separate gas-fired storage water heaters rated at 105 kW each.

A sequence controller ensures that the most efficient boiler always takes the lead. Such operation is confirmed by the 'hours-run' meters on the boilers. The condensing boiler has operated for 6241 hours whereas the high efficiency boiler has only been required for 11 hours during two heating seasons.

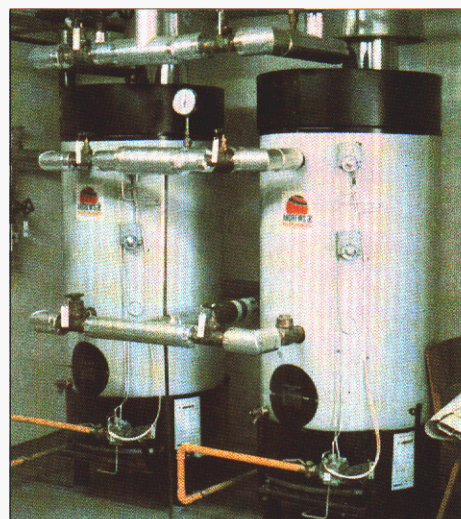
The radiators were replaced in the hospital during refurbishment. They were sized on an internal temperature of 22°C in order to provide a suitable environment for the elderly. These are modern high output panel radiators with covers to avoid any injury to the elderly. Two weather-compensated heating circuits supply older column radiators in the hospice. A further weather-compensated circuit supplies the hospital and splits into three zones controlled by three-port valves. This circuit operates at slightly lower temperatures than the one for the hospice and returns to the condensing heat exchanger separately.

Heating is available throughout the year in order to ensure that comfort conditions are maintained. However, the automatic controls keep boiler operation to a minimum. The system has a vertical balancing and sedimentation vessel situated between flow and return which helps to avoid sludging and pressure differential problems. In order to avoid the traditional daily window opening for freshening the rooms, a mechanical extract system has been installed. This is used for short periods throughout the day depending upon the occupancy.



Carter Bequest space heating boilers

The plant is controlled by a BEMS comprising one stand-alone outstation situated in the boiler house. This can be accessed via telephone modems from the estates department headquarters. The hospice is only used during the day and this zone is time-controlled in relation to occupancy. Although the hospital system was designed to operate at 82°C the estates staff have found that it can normally be run at less than this. By trial and error, they have found that the system can be operated successfully at 65°C flow temperature when the outside air is 0°C. The weather-compensator then automatically reduces the flow temperature in relation to the external temperature until the external sensor reaches 17°C when the boilers are shut down. This weather-compensation characteristic is reduced to a maximum 50°C flow during summer. The reduced-temperature, continuous-heating control regime makes this an ideal application for condensing boilers. With the return water nearly always less than 55°C, condensation occurs almost continuously, resulting in very high boiler efficiencies.



Carter Bequest storage water heaters

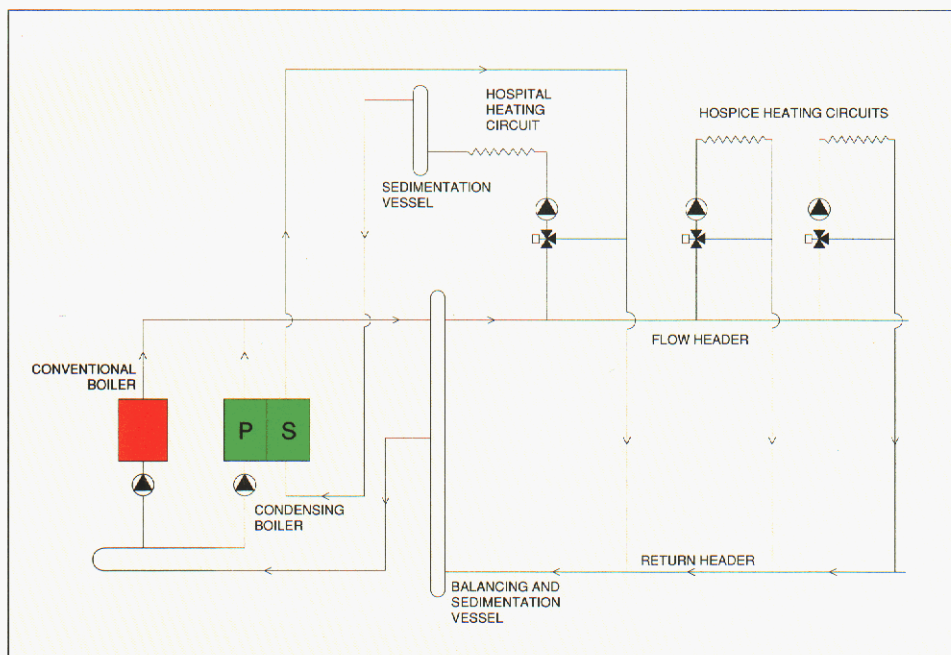
Two separate stainless steel flues leave the boiler room and combine into one chimney as the gases begin to rise. This avoids wet products of combustion reaching the non-condensing boiler. The flue terminal is a wire mesh to stop debris and birds getting down the chimney; it is used in preference to a conical terminal which could impede dispersal of the combustion gases. The condensing boiler has a drain for condensate with a trap to avoid combustion gases reaching the boiler room. The flue also has a drain and trap at its base to remove condensate formed in the chimney. These drains are made from ordinary plastic waste pipe which is unaffected by the mild acidity of the condensate.

Economic appraisal

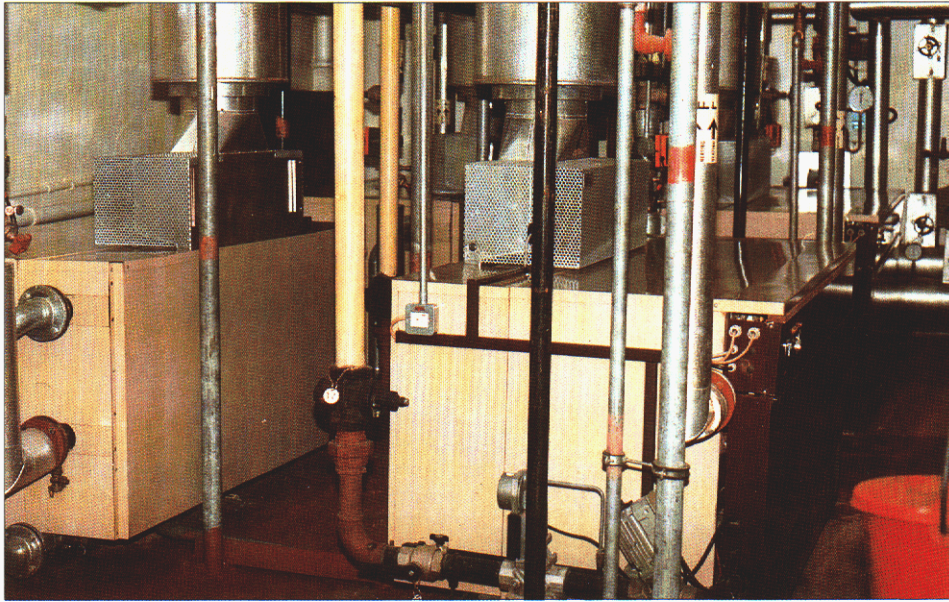
The only additional cost of installing condensing boilers was the extra cost of the boiler itself. In fact, the flue system was cheaper than that for a conventional boiler as it was only single skin and of a smaller diameter. An economic appraisal by the design team recommended condensing boilers as the most economic option, predicting a simple payback of about 1.2 years. Since the appraisal a number of factors have been changed such as the size of the condensing boiler, thus altering the costs and savings involved. Based on an additional capital cost of £5100, the actual payback is estimated to be around 2.2 years (see table on p.4) indicating that the condensing boiler has proved to be a sound investment.

Reactions

The Hospital Manager regards the new heating system as an important element of the service which the hospital provides for its elderly patients. Staff in the estates department are happy with the performance of the plant and in particular feel that the condensing boiler has proved to be reliable and cost-effective. The Energy Manager cites Carter Bequest Hospital as one of his most efficient buildings and the Maintenance Manager has not noticed any additional maintenance burden from the condensing boiler. The designer is also pleased with the installation and is currently considering installing condensing boilers on another site.



Carter Bequest system diagram



Bolingbroke boiler

BOLINGBROKE HOSPITAL, WANDSWORTH AREA HEALTH AUTHORITY

Founded in 1880, Bolingbroke Hospital in Wandsworth has 110 beds in six wards and cares for geriatric patients. The hospital was one of the first in the country to provide a 'long stay' unit. The hospital also has teaching facilities for doctors, an X-ray department and a large outpatients department.

The building itself is a medium/heavyweight brick construction on five storeys with a mixture of pitched and flat roofs with single glazing throughout. Changes made to the building services won a British Gas GEM (Gas Energy Management) award in 1989.

System

From 1935 to 1970 the hospital was heated by hand-stoked, coal-fired Lancashire boilers supplying steam. In 1970, they were converted to oil, but in the mid-1980s breakdowns became frequent. In 1987, they were replaced by four Potterton gas-fired, natural draught, condensing boilers each rated at 348 kW. This installation also included an AES 40 kW combined heat and power (CHP) unit and a conventional gas-fired storage water heater. The condensing boilers supply the space heating requirements and the CHP supplies the majority of the domestic hot water (DHW) demand, supplemented by the water heater. A building energy management system (BEMS) provides a flexible means of controlling both the plant and the systems.

The four boilers are sequenced and operate in parallel to feed main flow and return headers. The new design flow and return temperatures are 60°C and 49°C respectively. The original heating system was sized generously many years ago. Experience has shown that it can be operated satisfactorily at these lower temperatures, and these were used as operating parameters for the new plant. There are three main space heating circuits; two consist of radiators and one of radiant panel heating. All three are variable temperature weather-compensated circuits. During

exceptionally cold weather the flow temperature is raised by 10°C to ensure the comfort of the patients.

The stainless steel flue runs across the plant room and is connected to a brick chimney with a stainless steel liner. The flue is fan-assisted due to the height of the building and is fitted with a conical terminal. Individual condensate drains are run in plastic with traps from each boiler and the flue.

Economic appraisal

Wandsworth's Energy Manager claims a cost saving of 36% since replacing the old steam boilers. The new system is also said to have greatly improved patient comfort and considerably reduced maintenance. The BEMS makes the system easy to control and monitor and the whole system is now more responsive to changes in weather conditions. The controls and the stainless steel flue would have been installed

had conventional plant been installed. Whilst the payback would have been improved by installing a proportion of conventional boiler plant, the condensing boilers have paid for themselves in just over two years (see table on p.4).

Reactions

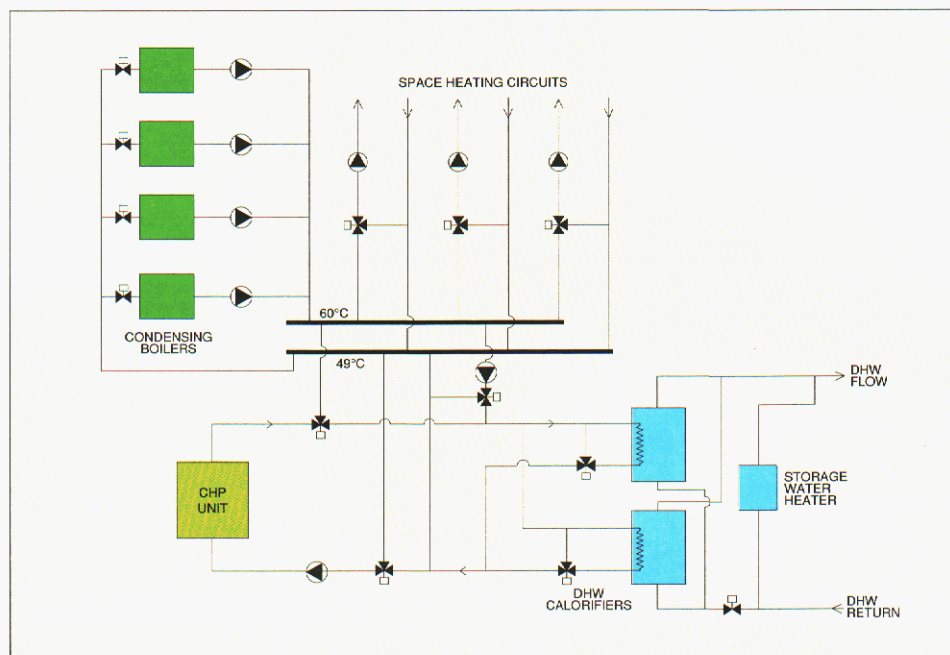
The Hospital Engineer feels that the system, and the boilers in particular, are now running well. Only three boilers are required in cold weather and the fourth boiler acts as a backup for the heating load and for the CHP unit. The Hospital Engineer also says that the boilers have had no more maintenance problems than a conventional boiler and he would certainly install condensing boilers again.

BLETCHLEY COMMUNITY HOSPITAL, MILTON KEYNES AREA HEALTH AUTHORITY

Bletchley Community Hospital, near Milton Keynes, began as a medical and surgical unit. The site now provides 23 beds for short stay geriatric patients alongside a child guidance clinic and an outpatients department (since the development of Milton Keynes General Hospital).

The hospital was built in the late 1960s and various alterations have been made since then. At one stage, the site accommodated occupational therapy and child guidance units, a residential ward block with an outpatients department and Bletchley Ambulance Station. Following a programme of boiler decentralisation, the ward block and the child guidance clinic now have separate heating plant which both include condensing boilers. This Case Study concerns the heating system in the ward block.

The ward block is a single-storey, lightweight construction with a flat roof. It was one of the early 'Oxford' designs with an 'undercroft' housing all the services. It is essentially rectangular in shape with two small enclosed courtyards. The building has a steel frame clad with preformed insulated steel panels which have a relatively good U-value for a 1960s construction. The site won a British Gas Southern Region GEM award in 1990 for its efficient use of gas.



Bolingbroke system diagram

	Estimated annual running cost (conventional system) £	Estimated annual running cost saving (condensing element) £	Estimated percentage saving %	Overcost (condensing element) £	Approximate payback period (condensing element) years
Carter Bequest	13 700	2300	17	5 100	2.2
Bolingbroke	40 200	5900	15	12 400	2.1
Bletchley	5 550	1000	18	1 900	1.9

Estimated economics of the condensing boiler installations compared to new all-conventional systems. In all cases savings are quoted on the basis of the same useful heat delivered to the building, ie room temperatures are unaffected.

System

The heating and hot water were originally provided by centralised oil-fired boilers. Underground mains supplied low pressure hot water (LPHW) to radiators and DHW calorifiers in all three buildings on site. These underground mains suffered from leaks and corrosion. Heat losses were high, due to the lack of pipe insulation and poor boiler efficiencies during summer. An assessment of the situation showed that decentralised boiler plant would be more suitable.

The ward block boilers were installed in January 1987 and new panel radiators were installed in October 1987. It is a single zone, two pipe heating system and the boilers also provide DHW via plate heat exchangers and storage vessels.

The ward block has two atmospheric gas-fired Atlantic boilers rated at 116 kW each, situated in a boiler house below ground level at the back of the building. One is a 'Maximagaz' double condensing boiler and the other an 'Optimagaz' high-efficiency, non-condensing boiler. The condensing boiler has two extra stainless steel heat exchangers. The first heats the return water from the space heating system and the second heats the cold feed to the DHW. This reduces the flue gas temperatures even further, taking the boiler into deep condensing mode when instantaneous efficiencies of well over 90% are achieved.

A header is installed between main flow and return pipes, acting as a balancing and sedimentation vessel. A further sedimentation vessel is installed on the heating return. Whilst the Optimagaz is not a condensing boiler, seasonal efficiencies of 80-85%, attributable to its good design have been reported elsewhere. Two features of its design are the high levels of insulation and the preheating of combustion air. The boilers are sequenced such that the Maximagaz always takes the lead. A BEMS provides weather compensation via a three-port valve on the space heating system. The DHW system consists of two 960 litre storage vessels supplied by two external plate heat exchangers.

Both boilers are connected to a flue header which is divided by an internal vertical plate to

prevent the flue gases coming together until they rise. The stainless steel flue rises about 1 m above the roof of the building. The lack of a flue terminal promotes the dispersal of the low temperature combustion products. The condensate drains from the flue and both condensing heat exchangers are run in standard plastic waste pipe to a pumped sump. There are traps on the condensing boiler's condensate drains to avoid gases escaping into the plant room.

Economic appraisal

The condensing boiler can be seen to condense almost continuously. The Maximagaz has run for 13 000 hours since January 1987 whereas the non-condensing boiler has only run for 4000 hours. This indicates that the most efficient plant is taking the majority of the load and shows an average hours run of about 3250 hours per year. The double condensing boiler has resulted in improvements in boiler efficiency of about 17%. This has produced a very attractive payback period of 1.9 years.

Reactions

The District Engineer is very happy with the boilers which have proved to be very reliable during the 13 000 running hours and feels that it is a good installation. The health authority carry out their own maintenance. There is very little extra maintenance other than the washing down of the condensing heat exchangers. The enhanced system control has also provided improvements in comfort conditions. The engineers expect around 15-20 years life for the boilers. They say that they would install them again, as the high efficiencies are very attractive. As a consequence, serious consideration is given to using this type of high efficiency plant wherever new boilers are required.

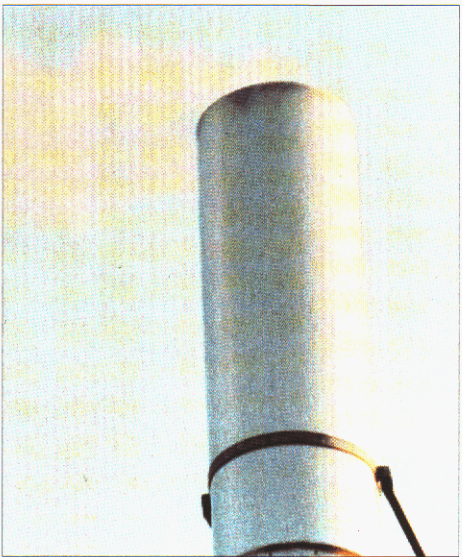
CONCLUSIONS

These three Case Studies have shown that condensing boilers are a viable proposition in hospitals. All the engineers concerned are happy and would install condensing boilers again. They have proved to be reliable and economic whilst maintaining comfortable conditions in the hospital. In addition the savings on fuel costs can be used to enhance patient care.

Further information

This Good Practice Case Study is one of a series on the use of condensing boilers in various building sectors. Good Practice Guide 16 provides practical information on installing condensing boilers in large buildings, it is available from BRECSU (see footnote). The Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM3: Condensing Boilers gives detailed guidance on all aspects of the subject. This covers appliance selection, new application yardsticks, system design and economic evaluation.

The information presented in this series of Case Studies has been taken from material provided by the users and from site visits carried out by independent consultants. Where possible, economic figures have been calculated from the fuel bills. Estimates have been made in cases where these were not available. The co-operation of the owners, designers, managers and occupants of the Case Study buildings is gratefully acknowledged.



Bletchley Community Hospital's boiler flue (plume shows it is in condensing mode)